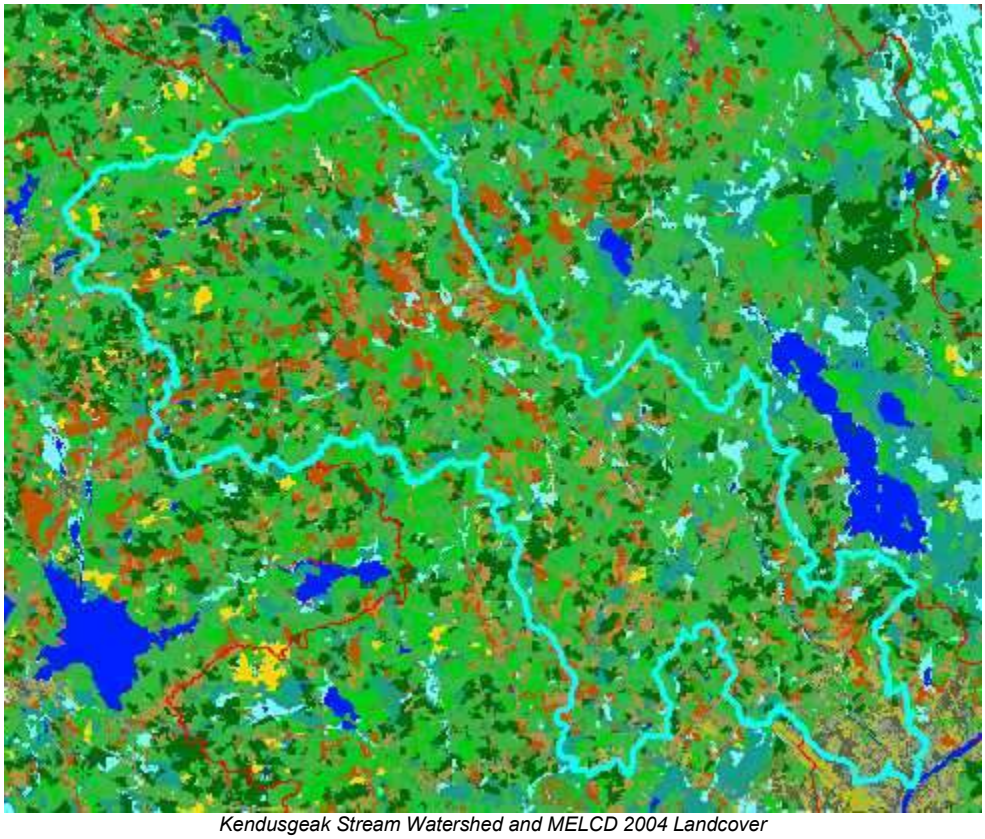
Intermediate ArcGIS 9 - Landcover Analysis

Prerequisites: Introduction to ArcGIS 9 - Basic Concepts, Intermediate ArcGIS 9 - GIS Data Concepts
Estimated Time: 4 hours

Downloadable PDF version of this class (1.8 MB)

The purpose of this class is twofold - to introduce people to the possibilities for using the National Landcover Dataset 2001 (NLCD 2001) and the Maine Landcover Dataset 2004 (MELCD 2004) products with GIS, and to provide an introduction to raster analysis with Spatial Analyst in the process. Students will already need a basic understanding of GIS, how to use ArcGIS, and a familiarity with raster data.

This class is a review of the data and associated tools, there are no exercises.



Kendusgeak Stream Watershed and MELCD 2004 Landcover

This class requires a basic understanding of raster data, and familiarity with ESRI's ArcMap application. We recommend completing the prerequisite classes listed above, as this class will NOT review these basic concepts.

Intermediate ArcGIS 9 - Landcover Analysis

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Course Introduction
- Introduction
- Outline

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- Landcover data
- Getting the data
- Layer files and MXDs
- Changing symbology
- Consolidating classes
- Identify tool

Overview of Data
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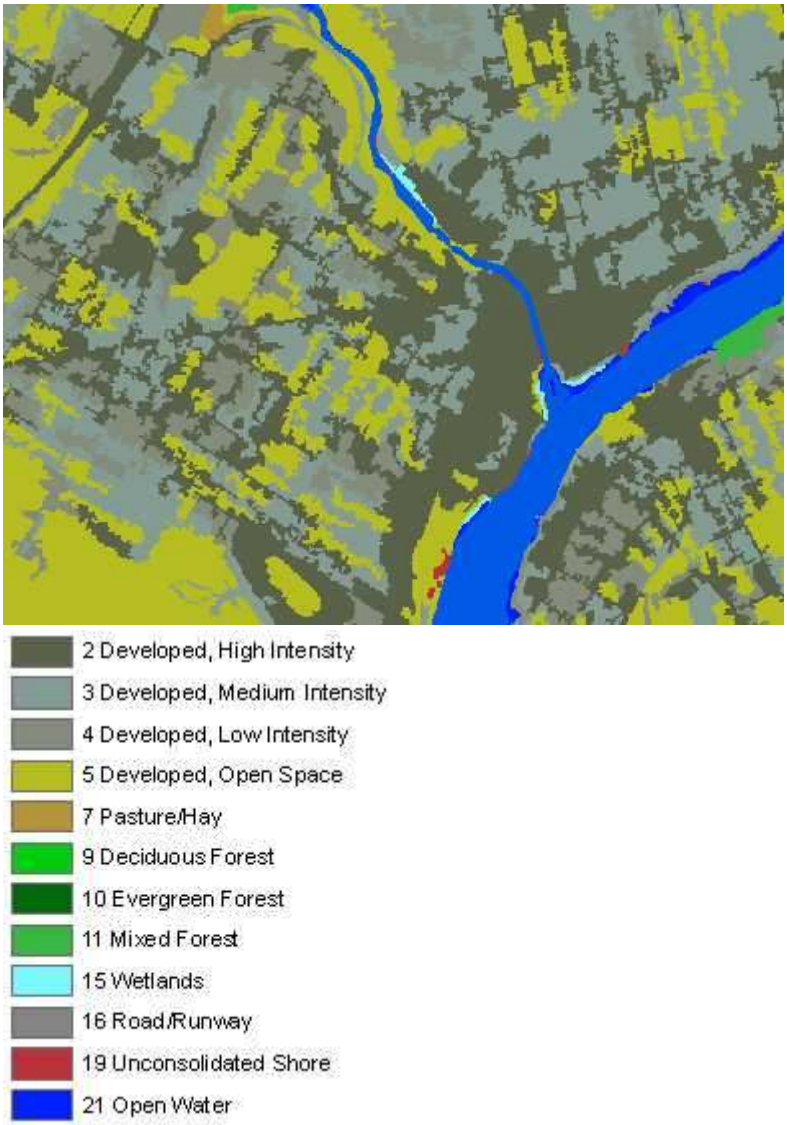
- NLCD products
- Satellite data
- Review of legacy data
- TIFF data format

Spatial Analyses
- Licensing
- SA Toolbar
- SA Options dialog
- Mask vs. Window
- ArcToolbox
- Tabulate Areas
- Landscape Analysis

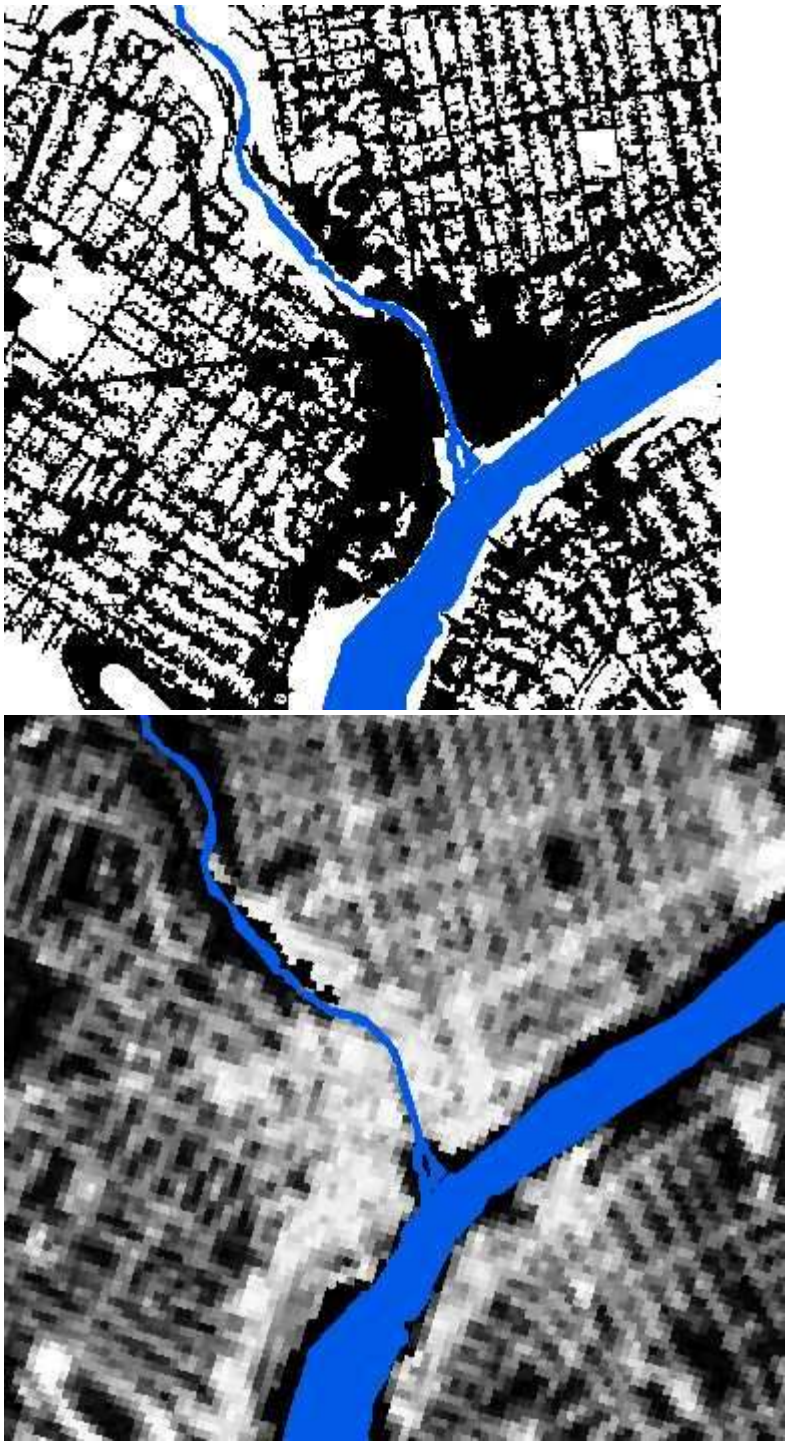
Getting Started - What are Landcover Data?

Concepts:
landcover
imperviousness
classes

Landcover data are spatial data which indicate, for a particular area, the type of dominant vegetation or man-made landscape. Typically, these categories are divided into landcover 'classes'. The group of classes is referred to as the landcover 'classification' for the layer. An example of a landcover class is "Deciduous Forest" or "High-intensity Developed". Imperviousness data are related to landcover data, and indicate for a particular area whether or not water may pass through into the ground. Some imperviousness classifications are based on percentages (i.e. an area is 50% impervious) while others may be a simple yes/no (i.e. the area is impervious).



Landcover of the Bangor area at the mouth of Kenduskeag Stream. Legend shows the classification from MELCD 2004 data, subset just for this area.

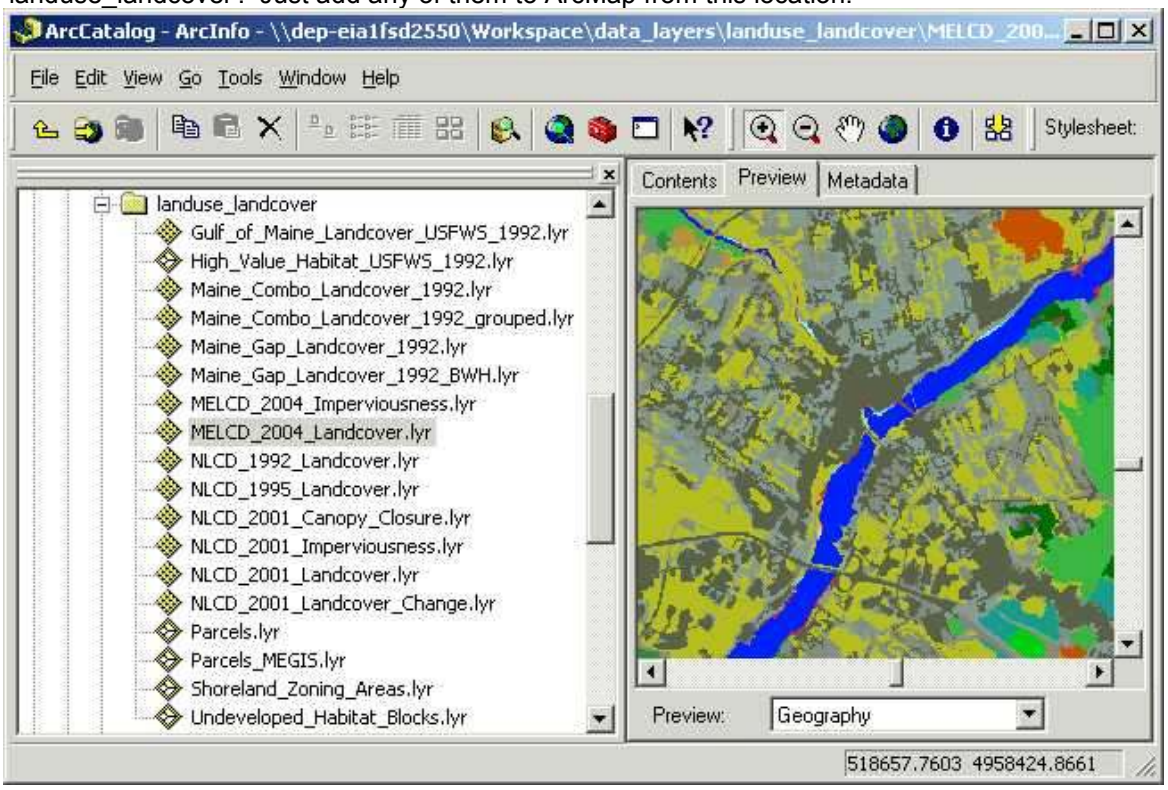


Two examples of imperviousness data, MELCD 2004 (top) which is a simple yes/no classification at a 5m resolution, and NLCD 2001 (bottom) with classes of impervious in 10% increments at a 30m resolution. The former has better spatial resolution, the latter has better thematic resolution (more about that in section 2).

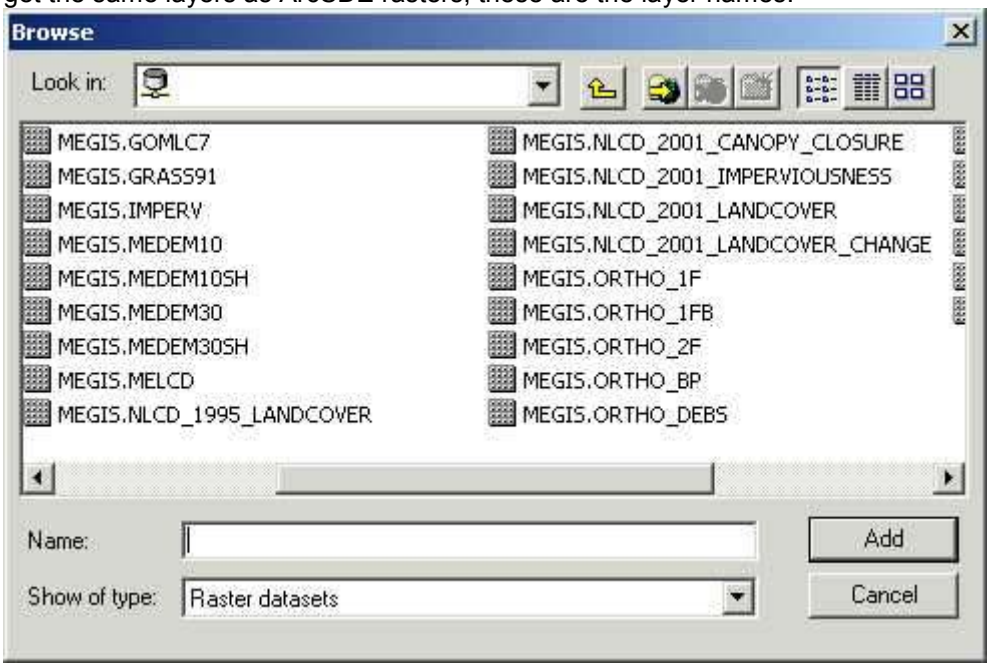
Getting the data

Concepts:
layer files for DEP users
ArcSDE layers for state agencies
MEGIS data catalog for everybody else

DEP users
Like most other GIS data, you can find these layers in the folder workspace\data_layers, under 'landuse_landcover'. Just add any of them to ArcMap from this location.



ArcSDE layers for State of Maine employees
Anybody connected to the State of Maine WAN can connect to the MEGIS ArcSDE server and get the same layers as ArcSDE rasters, these are the layer names:



Contact the Maine Office of GIS to get access to the SDE server if you don't already have access.

Everybody else
Anybody outside the State WAN can use one of three methods to access the data, you can either download the data directly from http://megis.maine.gov/catalog, use the ArcIMS orthomap service http://megisims.state.me.us/website/orthomap, or contact the Maine Office of GIS for a DVD-R with all the data. The ArcIMS service can either be used in the viewer link provided above, or can be connected directly to ArcMap. The IMS service only provides the MELCD 2004 landcover data.

This class is designed for DEP users and will thus refer to the layer files above, but the tools shown here will apply to all 3 groups of users.

Layer files and MXDs

Concepts:
layer files included with the data
map documents included with the data

This page does not apply to DEP users. It only applies to people who downloaded the data from MEGIS or who received the DVD.

Users who either downloaded the data from MEGIS, or who received a DVD, will also be able to utilize template ArcGIS layer files and/or map documents (MXD files). These are just designed to make it easier to make simple maps using the MELCD landcover data.

When you first copy these to your hard drive, they will likely not work. That is because layer files and map documents encode the data path inside them, and unless it is exactly the same as when they were first created - an unlikely scenario. You will likely see a red exclamation point next to the layer:

To fix this, just reset the data source in ArcMap. Right-click the layer, bring up its properties, and on the 'Source' tab, click 'Set Data Source', and navigate to where you stored the data.

Changing symbology

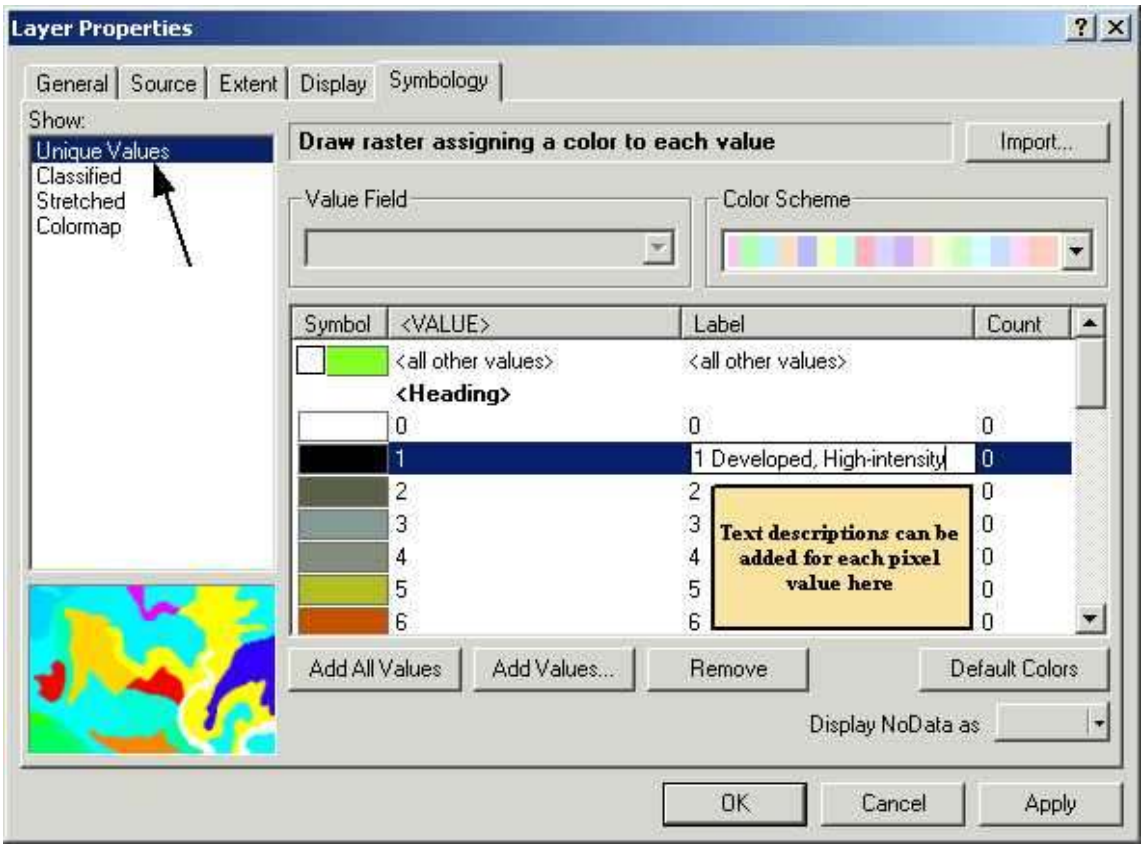
Concepts:
- **raster colormap**
- **unique values classification**
- **stretched symbology**

When you use the landcover data, you may find that the symbology used is not what you would like to see. In the case of landcover data, a **raster colormap** is used, which assigns a color to each pixel value automatically. A colormap is fixed, the colors cannot be changed (at least not easily, one has to remove the colormap and load a new one which is beyond the scope of this class).

However, the layer can have a different classification applied, where an entirely different system of assigning colors to pixel values is used.

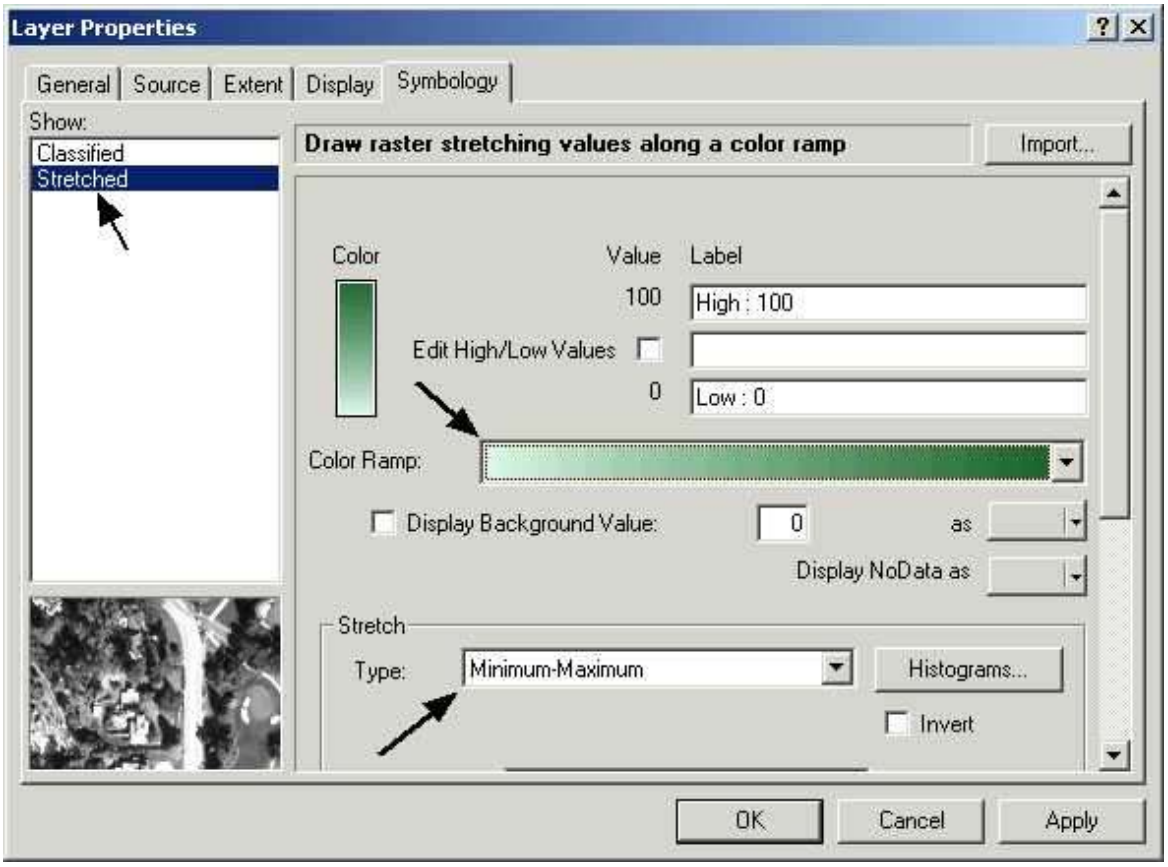
One such approach, using categorical data such as landcover data (where pixel values represent discrete categories), is the **unique values classification** in ArcMap. This is similar to a colormap, except that it is defined in the layer in ArcMap and can be easily changed by the user. This is the method used in both the sample layer file and MXD distributed with the data (and the layer file used by DEP users). The user defines what color is assigned to each pixel value, and which values are shown and which ones are not. It also can be used to simplify a classification without changing the data (i.e. 'clumping' classes).

To create a unique values classification, right-click the layer in ArcMap and bring up the layer properties. Click on the 'Symbology' tab, and select "Unique Values" from the list. The original colormap will be automatically translated, so the colors stay the same.



For data with continuous values, such as NLCD imperviousness and canopy data (more on these data layers later), using the **stretched symbology** is a better option. With those data, you typically want to indicate that higher percentages have more of a certain color. For a range of values from 0 to 100, for example, you may want to indicate the highest (i.e. 100% canopy closure) with one color, and the lowest (i.e. 0% canopy closure) with another, with all other values indicated by a ramp between the two extremes.

To create a stretched symbology, just choose "Stretched" on the "Symbology" tab, and choose the color scheme. Be sure to set the stretch type to "Minimum-Maximum".



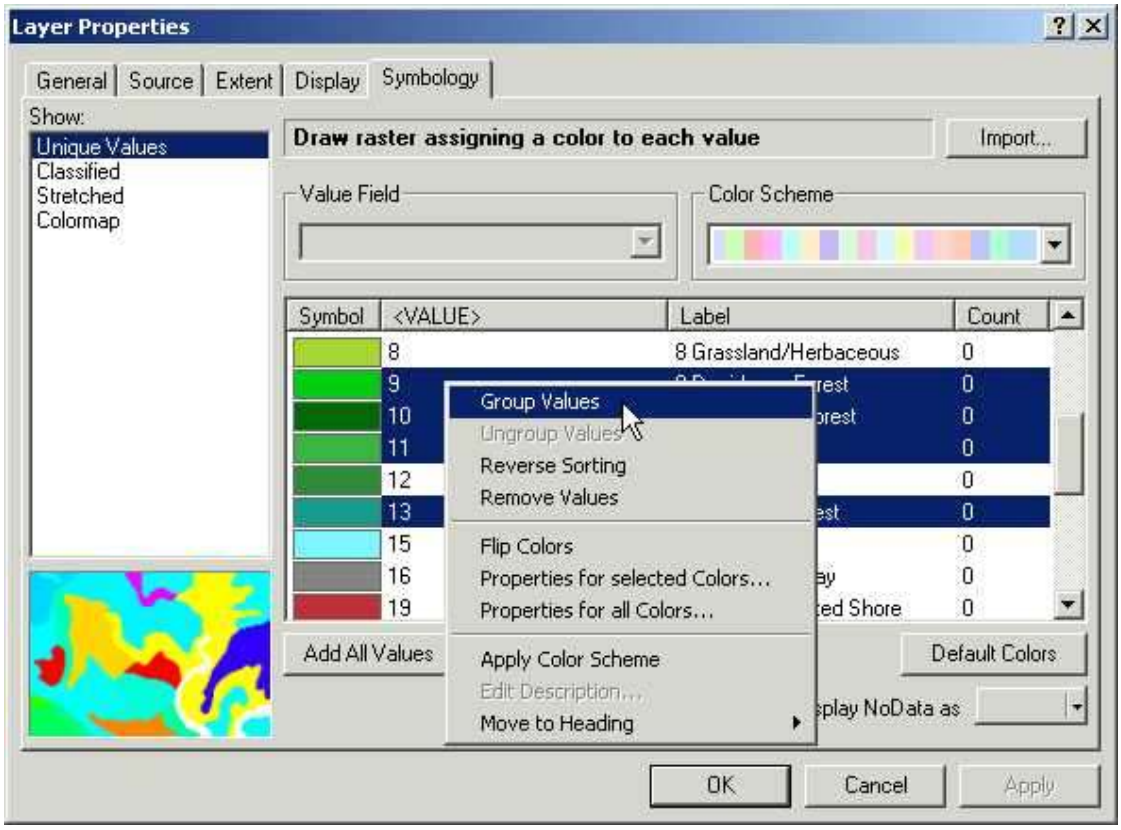
30-meter NLCD 2001 canopy data shown using a min-max stretch.

Consolidating classes

Concepts:
unique values grouping

Any unique values classification can be consolidated by **grouping** values together. For example, if a simpler classification is desired, such as consolidating all forested classes together, those pixel values in the unique values classification can be grouped in ArcMap. This does not change the source data at all, and is not a "reclass" (more on reclassing later).

Just click on the classes you want to group, right-click and choose 'Group Values'.

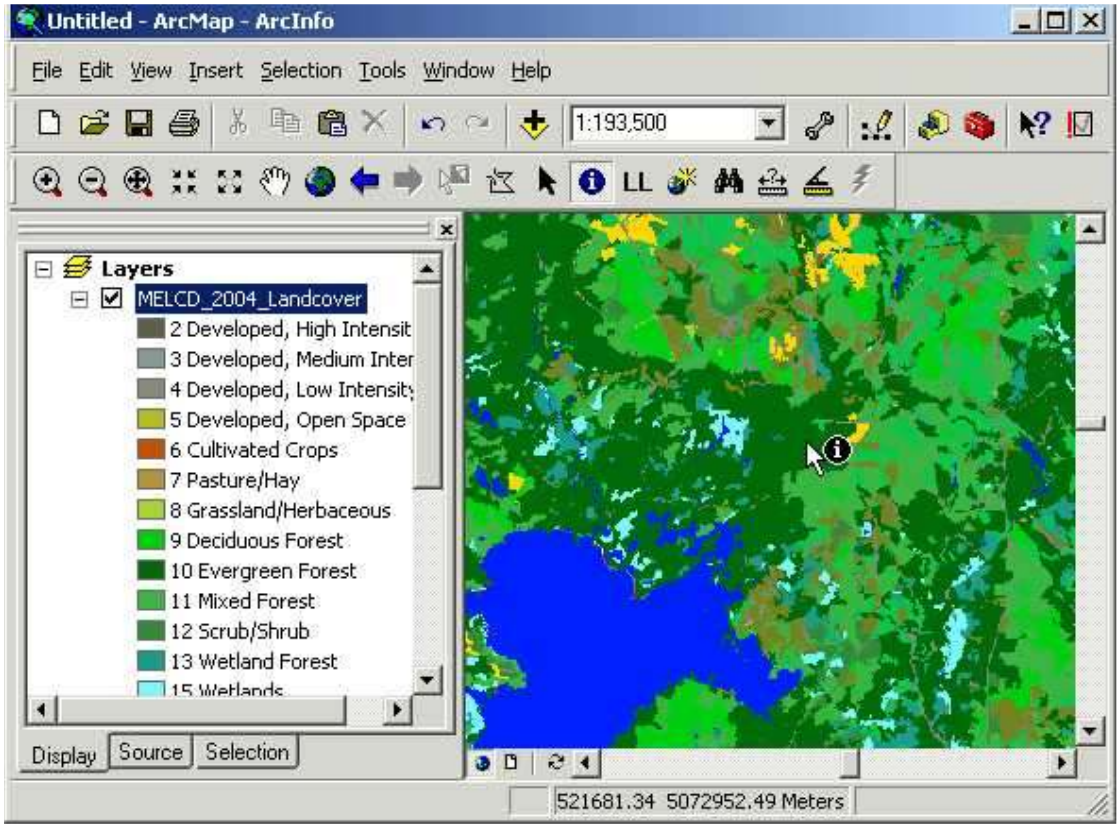


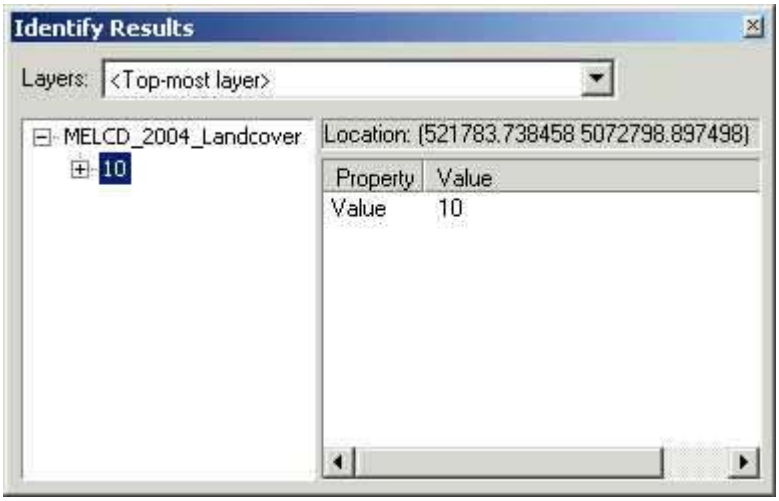
Identify tool

Concepts:
pixel values

The **pixel value** is the numeric value stored in the raster indicating what the pixel represents. When using the ArcMap Identify tool, it will only return the pixel value of a TIFF or ArcSDE raster (this is because at ArcGIS 9.1, attribute tables for these rasters are not yet supported).

Thus, if you are using ArcMap and "Identify" a pixel, you will just see a number returned, rather than a landcover class. In the case of canopy or impervious data, that number will indicate the percent impervious or canopy, but in the case of landcover data you have to look up the numeric value shown and find the related landcover class. Therefore, the Identify tool is of limited use with TIFFs or ArcSDE rasters at this time (side note - at 9.2, attribute tables are supported in all rasters, presumably this will work better then).





"Identifying" returns just the pixel value - 10 in this case. User must look up what this means - Evergreen Forest in this case.

MELCD 2004 Products

Concepts:
MELCD 2004 landcover
MELCD 2004 imperviousness
minimum mapping unit

In these next sections, we will cover all of the products available to end-users from the combined Maine Landcover Dataset 2004 (MELCD 2004) and National Landcover Dataset 2001 (NLCD 2001).

The MELCD 2004 products include a 5-meter resolution landcover dataset and a 5-meter resolution imperviousness dataset. This project was an integrated extension of the NLCD 2001 project for Maine.

MELCD 2004 Landcover
The landcover data are based on 2004 SPOT imagery fused (pan-sharpened) with 2001 LandSat data (5m black-and-white data were merged with 30-m color and infrared data, then classified). The pixel resolution is 5-meters, with a **minimum mapping unit** (MMU) of .89 acres. The MMU is the smallest area that can be accurately mapped. In practice, some areas smaller than the MMU are mapped in this layer, but they cannot be judged at the same level of accuracy as the rest of these data. Accuracy as a whole, based on a sample of 1671 points, is 75% according to the accuracy report. Maximum scale recommended for this dataset is 1:24,000; it is designed for analyses at the town or subwatershed level. For more complete information, read the metadata. The classification includes 23 distinct classes:

Pixel value	Class
2	Developed, High Intensity (80-100% impervious)
3	Developed, Medium Intensity (50-79% impervious)
4	Developed, Low Intensity (21-49% impervious)
5	Developed, Open Space (developed areas, but 0-20% impervious - city parks, golf courses, baseball fields, etc.)
6	Cultivated Crop (production of annual crops such as corn, potatoes, strawberries, and tilled barren fields)
7	Pasture/Hay (grasses are major vegetation, managed for harvesting as hay or grazing)
8	Grassland/Herbaceous (unmanaged grasslands - rare in Maine)
9	Deciduous Forest (> 20% tree canopy cover, > 75% of trees are deciduous)
10	Evergreen Forest (> 20% tree canopy cover, > 75% of trees are evergreen)
11	Mixed Forest (> 20% tree canopy cover, 25-75% are deciduous)
12	Scrub/Shrub (woody vegetation < 5m tall is > 20% of cover - typically regenerating fields, cuts, or rights-of-way)
13	Wetland Forest (freshwater wetland with > 20% tree canopy cover)
15	Wetland (all other wetlands)
16	Road/Runway (impervious road or runway, but not in developed areas)
19	Unconsolidated Shore (rocky shore, mudflats, sand beach, exposed lake shoreline)
20	Bare Ground (open quarries and pits, granite outcrops and peaks)
21	Open Water (water bodies typically > 10m wide)
22	Blueberry Field (commercial blueberry operations)
23	Recent Clearcut (forested area with > 90% canopy removal 2001-2004)
24	Light Partial Cut (forested area with 20-50% canopy removal 1995-2001)
25	Heavy Partial Cut (forested area with 50-100% canopy removal 1995-2001)
26	Regenerating Forest (forested area with canopy increase 1995-2001)
27	Alpine (shrubby or grassy vegetation above treeline on mountains)

MELCD 2004 Landcover data showing Bangor, Maine.

MELCD 2004 Imperviousness Data

The imperviousness data indicates, at a 5-meter pixel resolution, whether or not a pixel is 50% or more impervious (pixel value of 0) or <50% impervious (pixel value of 1) based on 2004 satellite data. Like the landcover data, the pixel resolution is 5-meters, with a **minimum mapping unit** (MMU) of .89 acres. The MMU is the smallest area that can be accurately mapped. In practice, some areas smaller than the MMU are mapped in this layer, but they cannot be judged at the same level of accuracy as the rest of these data. Accuracy as a whole, based on a sample of 1444 points, is 94% according to the accuracy matrix. Maximum scale recommended for this dataset is 1:24,000; it is designed for analyses at the town or subwatershed level. For more complete information, read the metadata.

MELCD 2004 imperviousness data in Bangor, black is impervious (with rivers in blue for reference - they would be considered pervious).

NLCD 2001 Products

Concepts:
NLCD 2001 landcover
NLCD 2001 landcover - 1995
NLCD 2001 landcover change - 1995-2001
NLCD 2001 imperviousness
NLCD 2001 canopy cover
thematic resolution
spatial resolution

The NLCD 2001 project is a national cooperative effort between many federal agencies (chiefly NOAA and USGS) to map landscape features and change consistently for the US. It arose from earlier circa-1992 efforts to map landcover (USGS' original NLCD project) and coastal changes (NOAA's Coastal Change Assessment Project - CCAP). The 2001 project varies tremendously from the original projects in several areas:
- accuracy is greatly improved
- NLCD 2001 and CCAP 2001 are entirely integrated (we will refer to them combined as just NLCD 2001 for simplicity)
- many more products are available to the end-user
- a single consistent mapping system is used for the entire country

The NLCD 2001 products formed the base for the MELCD 2004 products. The NLCD 2001 products have a greater **thematic resolution** than the MELCD 2004 products, meaning that they typically use more classes or provide more information about a mapped area. For example, the NLDC 2001 landcover product depicts seven types of wetlands, whereas the MELCD 2004 landcover only shows two. However, the trade-off is a lower **spatial resolution**, meaning that those mapped areas are larger in NLCD 2001 products than MELCD 2004 products. For example, in all NLCD 2001 products, the pixel size is 30 meters, with a minimum mapping unit of 2 acres. Compare this to a 5-meter pixel size and .89 acre MMU for the MELCD 2004 products. Spatial accuracy of the MELCD 2004 products are about 15 meters, while NLCD 2001 products have a spatial accuracy of about 60 meters. NLCD 2001 products are designed for use over larger areas and smaller scales, such as a maximum scale of roughly 1:100,000 and analyses conducted at the county or watershed level.

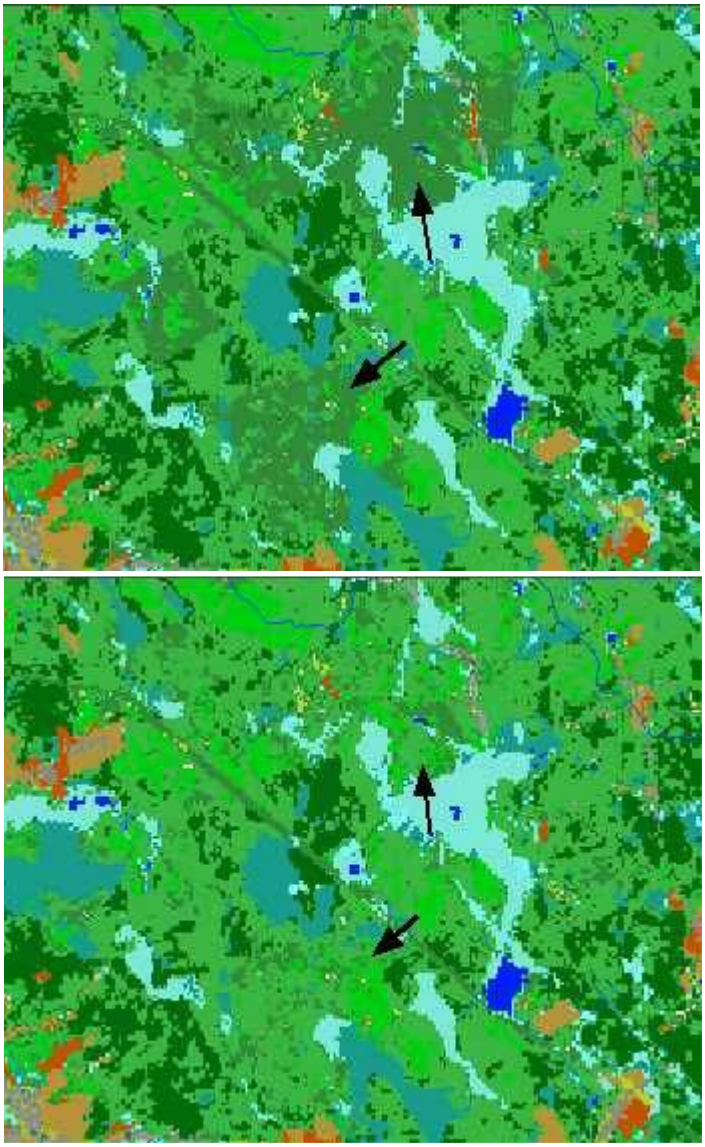
Our data covers the NLCD 2001 zone 66, which includes Maine and portions of New Hampshire and Vermont.

NLCD 2001 landcover

The most well-known product of the NLCD 2001 project is the 2001 landcover dataset, with 21 landcover classes in Maine (the full NLCD 2001 classification nationwide includes 5 other classes not found in zone 66); for details see the metadata. Accuracy is > 80% based on a sample of 697 points, for details see the error matrix. The classification includes:

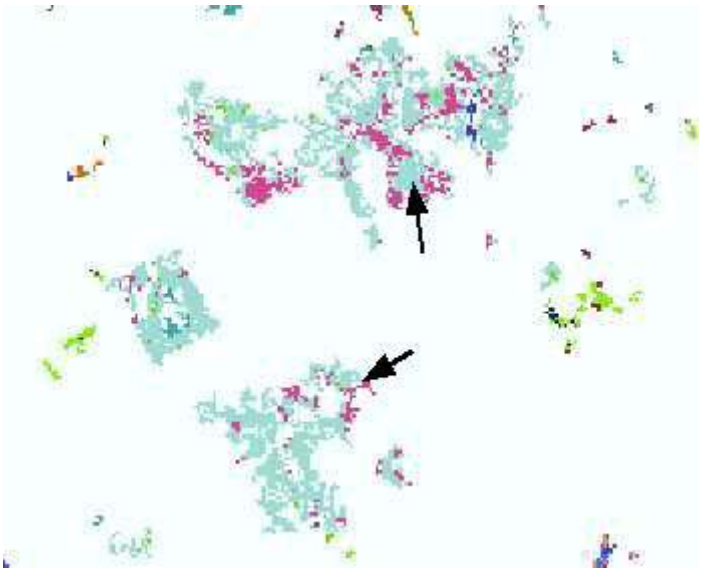
Pixel value	Class
2	Developed, High Intensity (80-100% impervious)
3	Developed, Medium Intensity (50-79% impervious)
4	Developed, Low Intensity (21-49% impervious)
5	Developed, Open Space (developed areas, but 0-20% impervious - city parks, golf courses, baseball fields, etc.)
6	Cultivated Crop (production of annual crops such as corn, potatoes, strawberries, and tilled barren fields)
7	Pasture/Hay (grasses are major vegetation, managed for harvesting as hay or grazing)
8	Grassland/Herbaceous (unmanaged grasslands - rare in Maine)
9	Deciduous Forest (> 20% tree canopy cover, > 75% of trees are deciduous)
10	Evergreen Forest (> 20% tree canopy cover, > 75% of trees are evergreen)
11	Mixed Forest (> 20% tree canopy cover, 25-75% are deciduous)
12	Scrub/Shrub (woody vegetation < 5m tall is > 20% of cover - typically regenerating fields, cuts, or rights-of-way)
13	Palustrine Forested Wetland (freshwater wetland with majority tree canopy cover)
14	Palustrine Scrub-shrub Wetland (freshwater wetland with majority scrub-shrub cover)
15	Palustrine Emergent Wetland (freshwater wetland with majority herbaceous cover)
17	Estuarine Scrub-shrub Wetland (estuarine wetland - salinity > 0.5% - with majority scrub-shrub cover)
18	Estuarine Emergent Wetland (estuarine wetland - salinity > 0.5% - with majority herbaceous cover)
19	Unconsolidated Shore (rocky shore, mudflats, sand beach, exposed lake shoreline)
20	Bare Ground (open quarries and pits, granite outcrops and peaks)
21	Open Water (water bodies typically > 30m wide)
22	Palustrine Aquatic Bed (freshwater algal mats, floating mats)
23	Estuarine Aquatic Bed (estuarine - salinity > 0.5% mats - seaweed, kelp, eelgrass beds)

NLCD 2001 landcover for 1995
Using the same exact methodology, but based on circa-1995 imagery, a second landcover map is produced for the purposes of change detection. It has the same properties as the 2001 landcover data. For details, see the the metadata.



Samples of 1995 (top) and 2001 (bottom) NLCD 2001 landcover data. Black arrows indicate areas where shrublands have regrown to mixed or deciduous forest in that time period. The location is in Kenduskeag and Glenburn in the Kenduskeag Stream watershed.

NLCD 2001 change 1995-2001
This layer depicts landcover changes that occured between the 1995 and 2001 datasets. There are 147 classes in this layer based on the number of change combinations occurring in zone 66. For details, see the metadata. *Note to users: those of you with DVD data will see additional classes which are unchanged (i.e. evergreen forest to evergreen forest). These have been removed in the data available for DEP, state users, and anybody downloading the data from MEGIS, since they actually indicate no change. DVD data pixel values for this layer correspond to the NLCD_VALUE field in the classes list linked above.*



The same area showin in the change data. Light blue indicates a change from scrub-shrub to mixed forest, magenta is scrub-shrub to deciduous forest.

NLCD 2001 imperviousness

This layer depicts the % imperviousness in each 30m pixels based on the 2001 LandSat data. This layer also has greater thematic accuracy than its MELCD 2004 counterpart (which has just a simple yes/no classification), but much lower spatial resolution (30m vs. 5m in MELCD 2004). Accuracy is estimated at 88%. For details, see the metadata. This layer was used to derive the developed classes in the NLCD 2001 landcover layers.

NLCD 2001 canopy closure
Another layer used to derive the NLCD 2001 landcover data is this one which depicts % canopy closure of trees in each 30m pixel. Accuracy is estimated at 93% based on cross-validation. For details, see the metadata.

(Top) NLCD 2001 imperviousness data in Bangor, darker pixels are more impervious, with black = 100% and white = 0%. This is in Bangor where Kenduskeag stream enters the Penobscot River. (Bottom) NLCD 2001 canopy data in the same Kenduskeag/Glenburn location as above. Darker green means more canopy with darkest green = 100% and white = 0%.

Satellite data

Concepts:
LandSat data
image bands
SPOT-5 data
reflectance
satellite sensor
mosaic
scene
panchromatic
license restrictions on SPOT data
fused data

In addition to the standard products provided for NLCD 2001 and MELCD 2004, we provide the satellite data if desired. These are the raw data which were used to derive the other products.

LandSat data
These are currently only available on the DVD and to DEP users (in data_layers\image_catalogs). LandSat data are 30-meter pixel data consisting of 7 **image bands** collected by NASA's LandSat 5 and LandSat 7 satellites. A band is a range of energy **reflectance** absorbed by a **satellite sensor**. Reflectance is merely energy reflected off Earth and detected by a sensor. The sensor is a machine mounted on a satellite which detects some type of energy. The LandSat satellites utilize a sensor called the Thematic Mapper (LandSat 5) or the Enhanced Thematic Mapper (LandSat 7). The data provided here is for 6 of the TM or ETM bands - 3 in visible light and 3 in infrared (bands 1-5 and 7), and are **mosaics** of satellite **scenes**. A scene is a single "picture" collected by the satellite, often they are merged together to cover a large area, forming a mosaic. Four mosaics are available (maps of the dates used are available):

Spring 2001 - scenes collected during the early growing season after snow-melt on the following dates: 5-7-2001, 5-8-2001*, 5-9-2001, 5-10-2001*, 5-25-2001, 5-4-2002*, 5-12-2002, 4-14-2003, 5-16-2003*, 5-17-2003. Metadata
Leaf-on 2001 - scenes collected during the summer growing season: 8-31-1999, 5-25-2001, 6-8-2001, 6-28-2001, 7-20-2001*, 6-4-2002, 6-21-2002*, 8-9-2002. Metadata
Leaf-off 2001 - scenes collected during the autumn season after leaves have dropped: 10-12-2000*, 10-22-2000, 9-30-2001, 10-1-2001*, 10-2-2001, 10-16-2001, 11-8-2001, 10-4-2002*, 10-12-2003*. Metadata
Leaf-on 1995 - scenes collected (mostly) during the summer growing season for the circa-1995 landcover: 9-25-1993*, 11-21-1993*, 8-25-1994*, 5-1-1995*, 5-31-1995*, 6-27-1995*, 7-4-1995*, 8-14-1995*, 9-6-1995*, 9-15-1995*, 8-30-1996*. Metadata
** indicates LandSat 5 data, all others LandSat 7.*

Each band of the LandSat data corresponds to a range of energy, 3 in visible light, and 3 in infrared.

Band	Wavelength range
1	450-520nm (blue light)
2	520-600nm (green light)
3	630-690nm (red light)
4	760-900nm (near-infrared)
5	1550-1750nm (mid-infrared)
6*	10,400-12,500nm (heat emissions)
7	2080-2350nm (far-infrared)

** band 6 is a 60m band is not included with our data. The sixth band in our data is actually band 7.*

ArcMap uses a red-green-blue display (RGB) and so only three bands can be viewed at a time. By assigning different bands to different colors, you can produce a variety of effects. For example bands 3-2-1 assigned to R-G-B produces a "true-color" image since visible light is used, a 5-4-3 will produce a "false-color" image since infrared energy is shown, but not visible to the human eye.

Leaf-off NLCD 2001 LandSat data for Bangor. Top is a 3-2-1 true color image, bottom is a 5-4-3 false color. The false color indicates moisture and vegetation - pink/purple are unvegetated, dark blue is water, and green indicates vegetation.

SPOT-5 data
These data are collected by the French SPOT-5 satellite and are currently only available to state of Maine employees and other licensed entities. They are not available to download from MEGIS, nor are they distributed on the MELCD 2004 DVD. The 2004 SPOT-5 data were used to refine the NLCD 2001 data to a 5-meter resolution, and update the date coverage for most classes to 2004. The SPOT-5 data are **panchromatic** meaning they only sense a single band of visible light, creating a black-and-white image. They are also **licensed**; they can only be distributed to licensed entities. See the metadata for details and a list of licensees. Licensed entities may request a copy of the SPOT-5 data from the Maine Office of GIS. The SPOT-5 data mosaic consists of 2004 scenes collected mostly during the summer.


The same area in Bangor, shown in SPOT-5 data. Note the much better spatial resolution due to much smaller pixel size (5m v. 30m).

Fused data
In order to derive landcover at a 5-meter resolution, the LandSat and SPOT data were **fused**, a process also known as merging or pan-sharpening. This process takes the pixel values from the 5-meter SPOT data and combines them with the pixel values from the 30-meter LandSat data to come up with a combined value using various statistical methods (which are way beyond the scope of this class!). If you are a remote sensing analyst with Erdas Imagine, you can download the merge model to see exactly how this was achieved. These data are also licensed since they are direct SPOT-5 derivatives, they fall under the same license restrictions. They are only available on a separate set of 5 DVDs available upon request from the Maine Office of GIS.

Images of a farm in Corinth, in the Kenduskeag watershed. Top left is the original 30-meter LandSat data shown in true color (3-2-1). Top right is the SPOT-5 data for the same farm. Note the much better spatial resolution at 5 meters, but only 1 black-and-white color band. Bottom is the fused product which uses the sharper edges of the SPOT-5 data combined with the all color/energy bands of the LandSat data. This fused data was then used to derive the MELCD 2004 landcover data.

Review of legacy data

Concepts:
- **NLCD**
- **Maine Gap**
- **Maine_combo**
- **CCAP**
- **Gulf of Maine**

We include on the DVD five datasets which historically have been widely used in Maine for landcover analysis. These are NOT part of the NLCD 2001 or MELCD 2004 projects, but in the interest of providing a thorough source for Maine landcover, they are included. All of these are available to DEP users (in data_layers\landuse_landcover). Some of them are available to state agency users on the ArcSDE server, and all of them are on the MELCD 2004 DVD. They all are based on LandSat imagery alone, with 30-meter pixel resolution, and imagery dates from 1986 to 1997. Accuracy for products of this era is far below what is achieved with NLCD 2001 and MELCD 2004.

National Landcover Dataset (NLCD)
This is the original NLCD project based on LandSat data scenes from 1988-1993 and contains 18 classes. It was the first project to map landcover consistently for the entire country at a 30-meter resolution. Metadata

Maine Gap
The Maine Gap Analysis Project mapped landcover with the purpose of modeling vertebrate fauna distributions. Although a national program within USGS, each state's project was undertaken independently with few exceptions. Maine's classification reflects the strong presence of managed forestlands in the landscape. LandSat scenes from 1991-1993 were used to create a dataset with 38 classes and an overall accuracy of 52% based on 41,120 samples from aerial videography (Hepinstall et al. 1999, p. 40). Metadata

Maine_combo
After much use, it was clear to some users at Maine DEP that NLCD had certain classes depicted better than Gap, and that Gap had others that were better than NLCD. These users were principally interested in estimating imperviousness from landcover class - so this perspective may not be shared by other users. The two products were merged based on a set of rules regarding which class had priority where pixels disagreed. This layer became widely used among watershed scientists in the state. Metadata

CCAP
The original NOAA Coastal Change Assessment Program (CCAP) was mapped on a scene-by-scene basis, so Maine has 3 different mapped areas. For each, a circa-1986 and a circa-1992 landcover dataset was created with 15 classes, along with change-detection data. Metadata

Gulf of Maine Landcover
US Fish and Wildlife developed this dataset which is an amalgamation of basically all the available landcover data for the Gulf of Maine basin as of 1997, including NLCD, Gap, CCAP, and wetlands data. Metadata

Cited: Hepinstall, J.A., Sader, S.A, Krohn, W.B., Boone, R.B., and R.I. Bartlett. Development and testing of a vegetation and land cover map of Maine. Maine Agricultural and Forest Experiment Station Technical Publication 173, 104 pp.

TIFF data format

Concepts:
TIFF
ArcSDE raster
ArcInfo GRID

The data provided are either in TIFF format (on the DVD) or as an ArcSDE raster. TIFF (Tagged Image File Format) files are a universal data standard which can be used in a wide variety of image processing and GIS software. ArcSDE rasters are just rasters stored in ArcSDE (the format Maine state employees will see in ArcGIS).

Both of these formats have some shortcomings when used in ArcGIS. The biggest is the inability to use a raster attribute table (a.k.a. value attribute table or VAT). Such a table contains additional fields aside from just the pixel's numeric value. For example, a "High-density Developed" pixel in MELCD 2004 will have a numeric value of 2. But with TIFF and ArcSDE, that's all the user sees, and must refer to the metadata or some other source to know what "2" means. An attribute table provides those extra descriptions right in the raster. This would be especially true for the NLCD 2001 change detection data, since there are 147 different classes.

People working outside Maine state agencies may want to consider converting the TIFF to an ArcInfo GRID. This is just another format for use in ESRI software, but it does have the advantage of using attribute tables for rasters. A text lookup table is included for landcover data on the DVD.

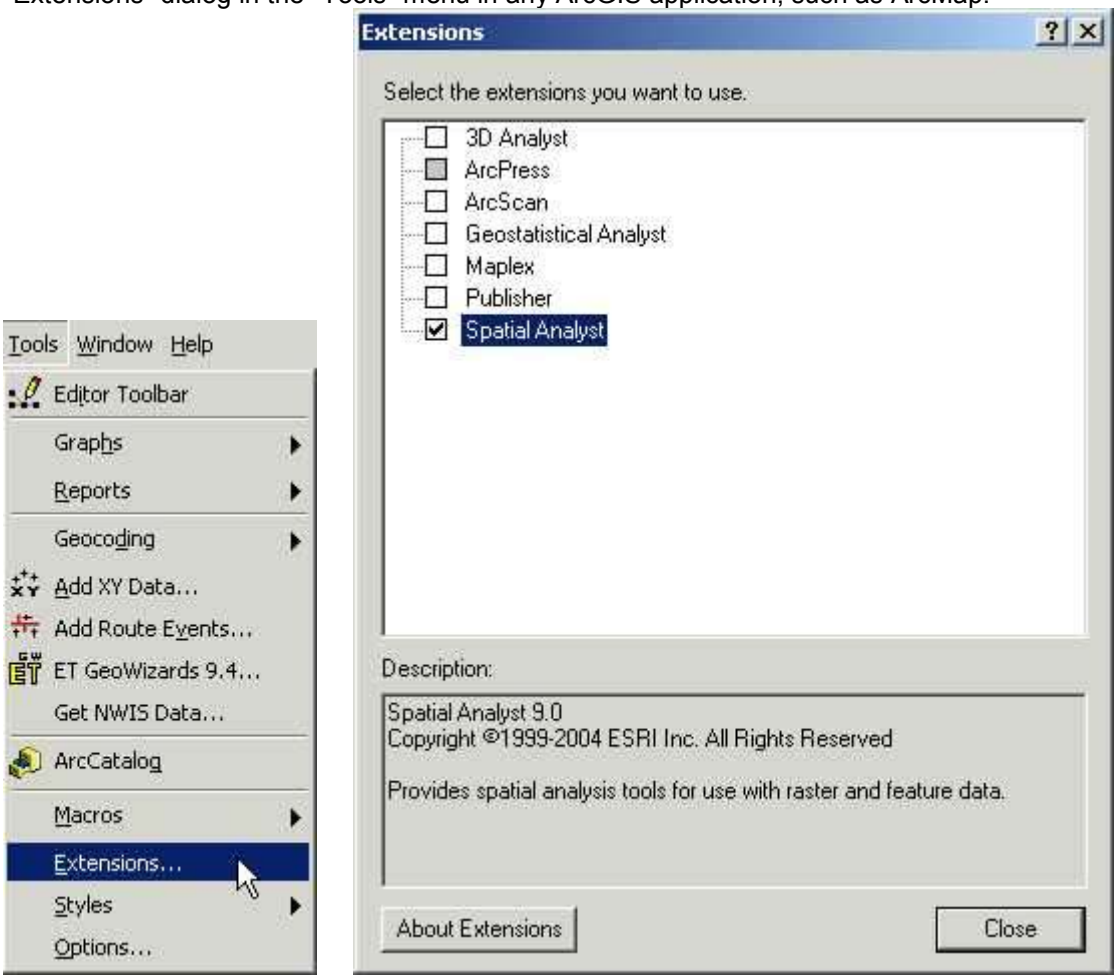
Spatial analyses - licensing

Concepts:
ArcGIS extensions
Spatial Analyst Extension

All of the analyses in the third section of this class require an **ArcGIS extension**. An extension is just an additional piece of software that can be added to ArcGIS for more funcionality. The **Spatial Analyst extension** is the ArcGIS extension used for raster processing, such as landcover and imperviousness analyses.

Spatial Analyst requires an additional license which you can obtain from ESRI. Maine state agency users will not need to do this, as licenses are already procured.

Once the license is installed, the Spatial Analyst extension can be enabled by using the "Extensions" dialog in the "Tools" menu in any ArcGIS application, such as ArcMap:



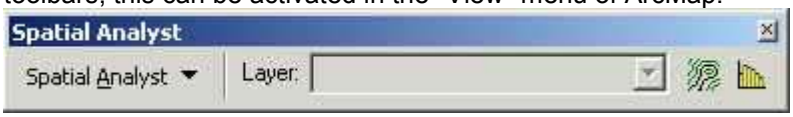
Tools menu - Extensions will bring up the extensions licensing dialog. A check-mark here indicates you have a license checked out.

IMPORTANT - you need to get into the habit of turning "off" the extension after you have used it. Otherwise, it will remain "on" every time you use ArcGIS (even though you may not be using Spatial Analyst), and you will be wasting a license. There are a limited number of extension licenses for Maine state users. Turn it "off" as soon as you're done using it.

Spatial Analyst toolbar

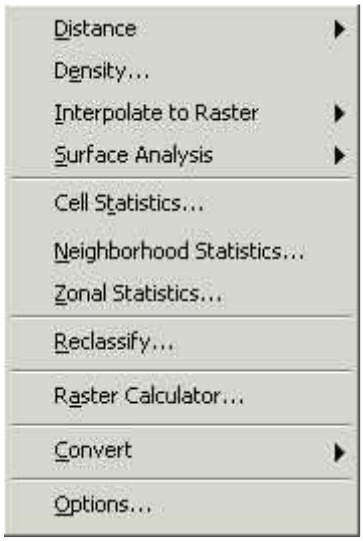
Concepts:
Spatial Analyst toolbar
Spatial Analyst menu

The ArcGIS Spatial Analyst has a set of tools available on the **Spatial Analyst toolbar**. Like all toolbars, this can be activated in the "View" menu of ArcMap.



Spatial Analyst toolbar

Most of the functionality is in the **Spatial Analyst menu**, which is available on the Spatial Analyst toolbar.



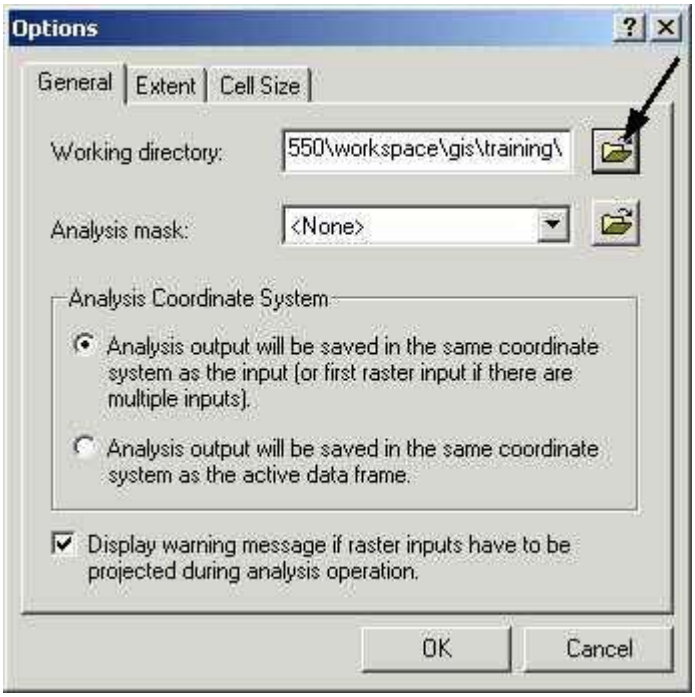
Spatial Analyst menu

This class will only demonstrate a few of the Spatial Analyst functions, as they relate to landcover analysis. For more information on Spatial Analyst functions, see the ArcGIS Desktop Help or the ArcGIS Spatial Analyst tutorial.

Spatial Analyst options dialog

Concepts:
Spatial Analyst Options dialog
working directory

An important dialog box is the **Spatial Analyst Options dialog**, which is brought up from the Spatial Analyst menu. The "Options" dialog contains many settings about Spatial Analyst that are important to the user for raster processing. One important setting is the **working directory**, this is where ArcGIS stores any temporary files it creates during raster processing (which can turn out to be a lot of data). It's important to set this someplace where this type of temp file is appropriate. For Maine DEP users, this should be a folder in 'workspace' where you have write permission.



The Spatial Analyst Options dialog, showing how to set the working directory.

Mask vs. window

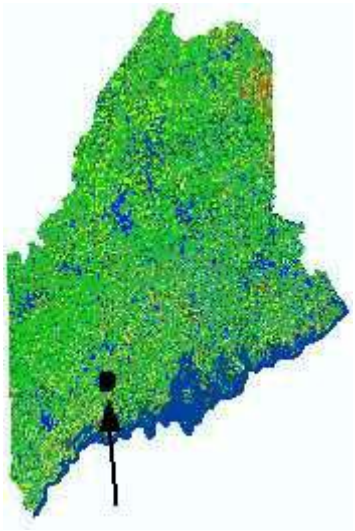
Concepts:
- **analysis mask**
- **analysis window**
- **analysis extent**
- **raster processing**

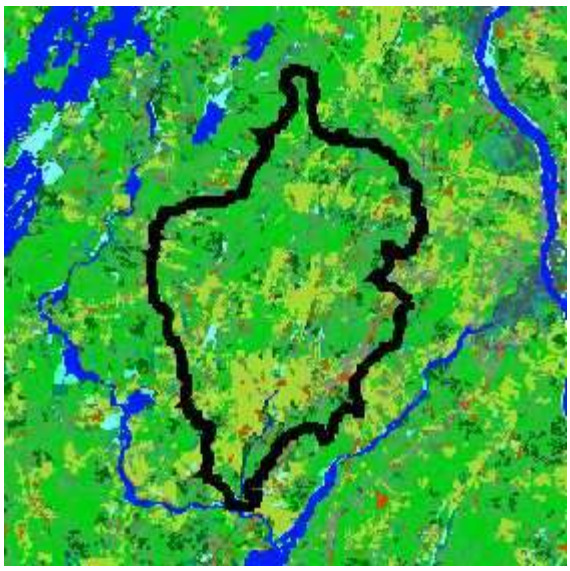
Two settings available in the Spatial Analyst Options are the **analysis mask** and **analysis window**, known in Spatial Analyst as the analysis extent. Both are ways of limiting how much area is analyzed in any Spatial Analyst operation.

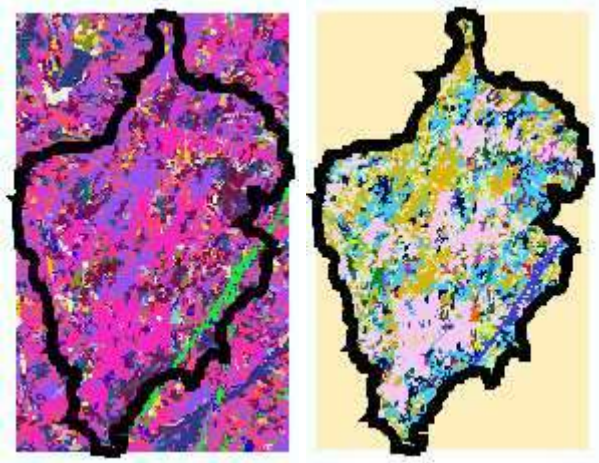
The analysis extent is always a rectangle and it is the absolute area to be analyzed. Any pixels outside the window are ignored and will not be represented in the **raster processing**.

Raster processing is how these types of analyses are run - typically an input raster has something done to it, resulting in an output raster.

The analysis mask can be any ArcMap layer, shapefile, coverage, raster, etc, and can be an irregular shape. Any pixels outside the mask are not computed in the Spatial Analyst operation (instead being assigned a value of NODATA). A watershed polygon is a commonly-used analysis mask.



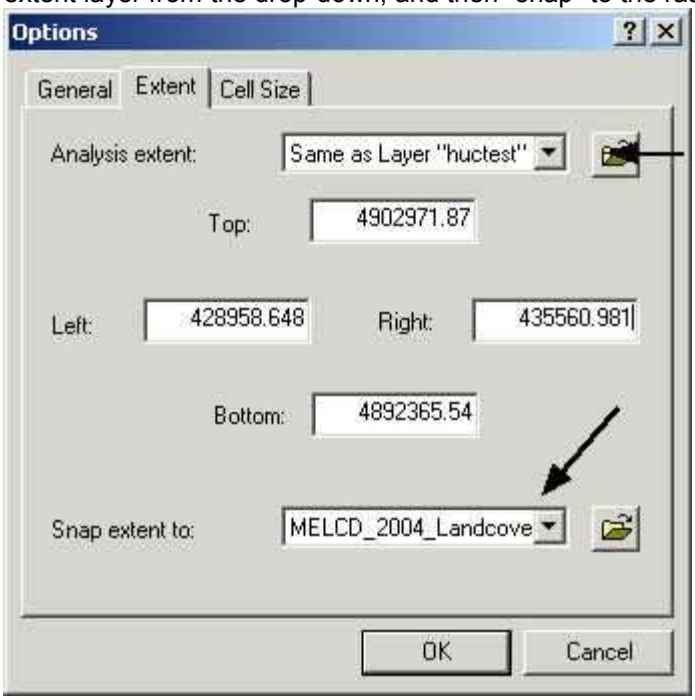




Examples of raster processing, extent masks, and extent windows. Upper left is the full State landcover layer. Upper right is just a zoomed-in area showing the watershed of interest. Bottom left is the output of raster processing using an analysis extent - note that pixels outside the rectangular area are not computed, but those outside the watershed (but within its rectangular extent) are. Bottom right is the output of raster processing using an analysis extent and an analysis mask - processing is limited to the rectangular extent of the watershed, and furthermore cells outside that watershed are computed as NODATA.

Setting the mask is easy enough to do - it's right below the working directory in the Options dialog. Just choose the layer you want for the mask from the list, or click the 'Browse' button to choose one.

Setting the extent is equally easy, it's in the Options dialog, but on its own tab. Just select the extent layer from the drop-down, and then "snap" to the raster you want to analyze.



Bugs

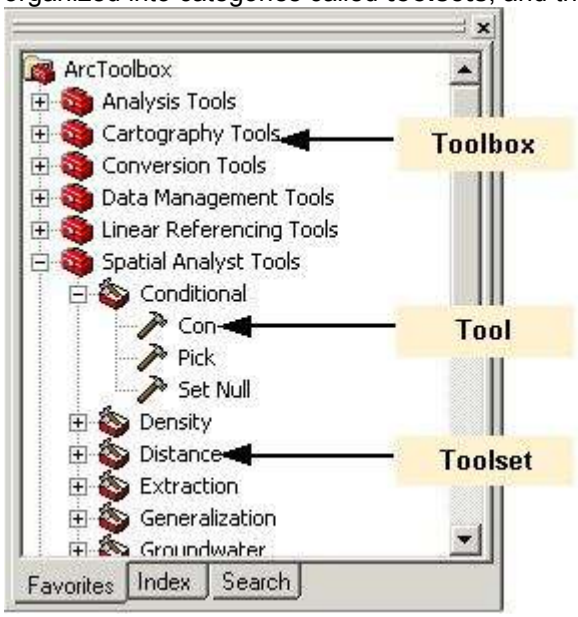
One bug involved in analysis masks and extents is that if you create a layer from a selected set (for example, a watershed selected), and use that selected layer as a mask or extent, Spatial Analyst will still use the entire watershed layer (i.e. the entire state) for analysis. To work around this, you must export the selected polygons as a separate shapefile and use that as the mask or extent.

Another bug involves projections. Although you can see data from different projections together in ArcMap (they are reprojected on-the-fly), this is ignored in raster processing. If you have a watershed in UTM coordinates and a raster in something else (like NLCD, which is Albers), and use the watershed as a mask or extent, the UTM watershed will likely not line up with the Albers raster, and you will get an output of NODATA or zeroes. The workaround here is that you have to reproject either the mask/extent polygon to the raster, or vice-versa. Typically the polygons are much easier to reproject.

ArcToolbox

Concepts:
- **ArcToolbox**
- **tools**
- **toolsets**
- **toolboxes**
- **Spatial Analyst toolbox**

A significant number of Spatial Analyst tools are found in **ArcToolbox**. ArcToolbox is activated by clicking on the toolbox icon  . It will come up in a separate window, typically docked in ArcGIS. It will show **tools**, which are the actual tools you use for geoprocessing. Tools are organized into categories called **toolsets**, and those are collected into **toolboxes**.



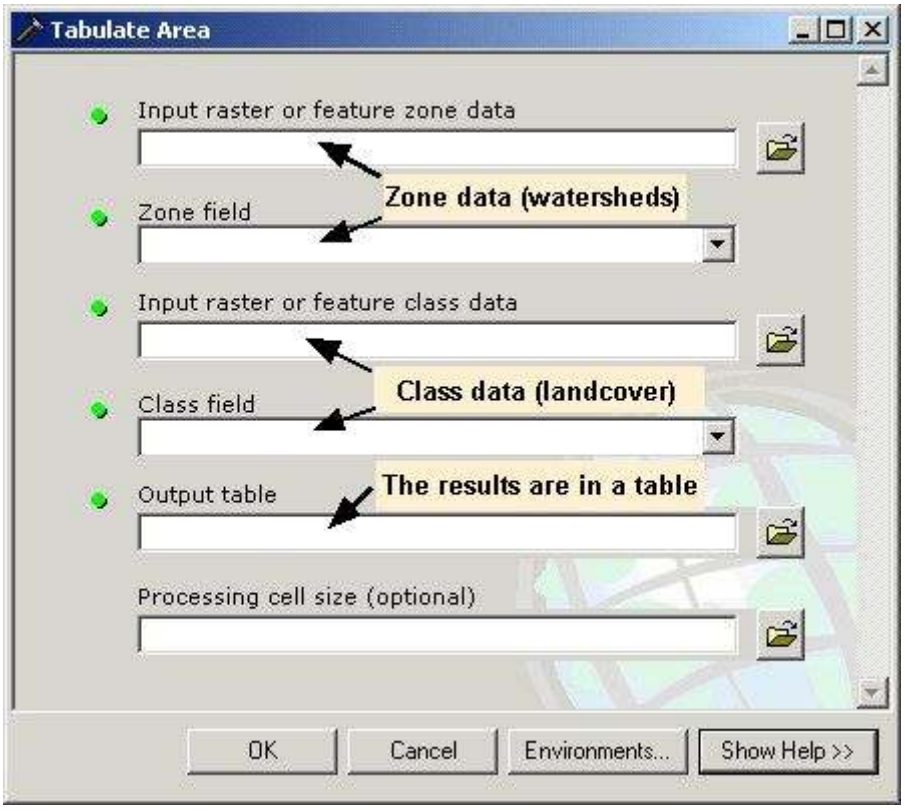
The **Spatial Analyst toolbox**, installed only with Spatial Analyst, has a number of tools for raster processing, only a few of which we will cover in this class. For more information on Spatial Analyst tools, see the ArcGIS Desktop Help or the ArcGIS Spatial Analyst tutorial.

Tabulate area

Concepts:
tabulate area

One of the simplest analysis tools is in the Spatial Analyst toolbox, in the "Zonal" toolset, is the **Tabulate area** tool. Within the analysis extent and window, it computes the area for each value of a raster. That is, for landcover it will compute the area for each landcover class, or for 5-meter imperviousness it will compute the total area that is pervious or impervious.


Linear Referencing Tools
Spatial Analyst Tools
Conditional
Density
Distance
Extraction
Generalization
Groundwater
Hydrology
Interpolation
Local
Map Algebra
Math
Multivariate
Neighborhood
Overlay
Raster Creation
Reclass
Surface
Zonal
Tabulate Area
Zonal Fill
Favorites
Index
Search


Tabulate Area
Input raster or feature zone data
Zone data (watersheds)
Zone field
Input raster or feature class data
Class data (landcover)
Class field
Output table
The results are in a table
Processing cell size (optional)
OK
Cancel
Environments...
Show Help >>

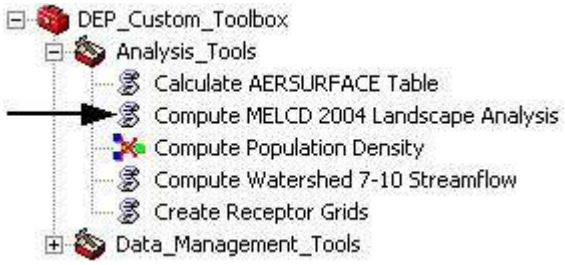
Landscape Analysis

Concepts:
landcover summaries
imperviousness estimate
watershed analysis

One of the most common uses of landcover data at DEP is to analyze the characteristics of an area, typically a watershed, for its landcover and/or imperviousness. A tool has been specifically developed to assist in this.

You must have the Spatial Analyst extension enabled for this tool to work.

You can find this tool in the DEP Custom Toolbox, under Analysis Tools:



This tool will create a table which provides the results of the analysis you choose. The output table **MUST** be in a geodatabase. Double-click the tool to bring it up. The tool can compute the following 3 analyses for every analysis area, any combination can be chosen:

MELCD 2004 summaries: Summarizes landcover classes into groups
MELCD 2004 classes: Will give a computation of the actual area of each landcover class
MELCD 2004 imperviousness: Provides a percent imperviousness computation

The area to be analyzed can include:

Polygons - each polygon in a data layer is analyzed separately. A unique ID field (must be numeric) is used to relate the output table back to the polygons. If multiple polygons contain the same unique ID, their results will be combined. If the layer is in ArcMap, and features are selected, only the selected set will be analyzed. Otherwise, the entire layer will be analyzed.

Hydro buffer - this choice has to be enabled in combination with at least one of the other analysis areas. It subsets the analysis area to be a user-defined buffer around lakes, ponds, streams, and rivers. For example, if you analyze by watershed polygons, and then use this option with a 100-foot buffer, the resulting area analyzed would be only the area within each watershed that is within 100 feet of a pond, lake, stream, or river. **Wetlands are not included in the buffer**.

Circular buffers - this works the same as polygons, but the polygon used for analysis is a buffer around a point layer. This is intended to allow analysis around sample points, or to limit watersheds to a certain distance from a sample point.

Note: You can choose either the polygon analysis, or the circular buffer analysis, or both. If you choose both, then the resulting analysis area is the intersection of the polygon and the sample point buffer. Also, if both are chosen, then they must have matching unique IDs so the script knows which point(s) go with which polygon(s). If a point does not have a matching point, the script will bail out. The hydro buffer cannot be run on its own (because doing so would attempt to

buffer and analyze all the water bodies in Maine, which would take weeks to run).

Non-DEP users can download the toolbox and script for use at their own site. The script will require some recoding to point to the correct datasets.